Mechanical aspects of the ID26 emission spectrometer II: improving stability for a large instrument by the use of multiple air pad supports

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Poster paper

Mechanical aspects of the ID26 emission spectrometer II: improving stability for a large instrument by the use of multiple air pad supports

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An instrument for X-ray emission spectroscopy (XES) based on perfect crystal Bragg optics was recently commissioned at beam line ID26 of the ESRF (European Synchrotron Radiation Facility). The spectrometer is used to record high-energy resolution fluorescence-detected X-ray absorption spectra with sub-lifetime resolution and to perform resonant and non-resonant XES. The hard X-ray probe is material bulk sensitive and allows demanding sample environments (*in situ* chemistry, high pressure, etc.). Spectrometers for XES are being installed or designed at almost all upcoming synchrotron radiation sources worldwide. The particularity of the ID26 spectrometer is to accommodate five analyser crystals with exact Rowland tracking in the vertical plane and with crystals radii between 0.5 and 2 m.The main upgrade of the new version of this large instrument (3 tonnes, overall size 2.5 m and height 3 m) is to allow the change of the scattering angle over the range 0–180°. This involves rotating the entire spectrometer around a vertical axis that passes through the sample. In order to optimize the vibration stability of the spectrometer's structure, we chose to support the structure in multiple points and not only on three (kinematic mount) like it is specified to do with air pads. According to this choice, we have developed special foot holders for air pads.The calculations during the design phase have shown that we can obtain a first modal frequency of the spectrometer's structure at more than 30 Hz. To confirm our predictive calculations, we have performed some vibration measurements.

1. Presentation of the ID26 emission spectrometer II

The main challenge of this spectrometer is to be able to maintain low errors of positioning between the three key entities: the sample, the analysers crystals and

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the detector (figure 1). The specifications for the positioning of the two latter entities are in the range of 50 μm in the vertical direction and 50 μrad for the Bragg angle; considering the large distance between elements (required by the crystals radii) and the large movements (Bragg angle 65–90°, scattering 0–180°), those specifications required a careful mechanical design.

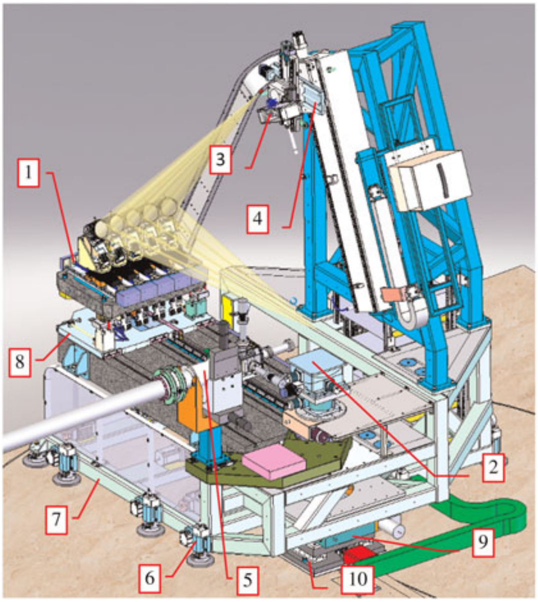

FIGURE 1. Some main components of the emission spectrometer II of ID26.

The core component of the spectrometer is the positioning unit for the analysers (figure 2). It consists of five motorized modules equipped with four axes (*X*–Chi–*Z*–Theta) enabling the positioning of each crystal with exact Rowland tracking (figure 3).

A second challenging point is to maintain a high stability on such a large instrument while permitting large displacements in the horizontal plane induced by the adjustable scattering angle (180°) and the adjustable horizontal position (100 mm). To perform that, the entire structure of the spectrometer (except for the sample column) is driven by a commercial circle goniometer and a special horizontal stage, and is also supported by 12 air pads on a polished marble floor. According to this choice to support the spectrometer's frame on multiple air pads, we have developed special foot holders for air pads (figure 4) which are adaptive to provide the right supporting conditions during the moving (kinematic conditions) and lockable to increase the stiffness of the supporting when the instrument is in position for the experiment.

2. Integration of multiple air pads on the structure – design and calculations

The supporting system of the spectrometer frame is composed of three 'master' points (two air pads directly coupled to the frame and a central coupling) and 10 'slave' points (air pads with an adaptive and lockable interfacing system called 'foot holder for air pads').

FIGURE 2. Analysers positioning unit.

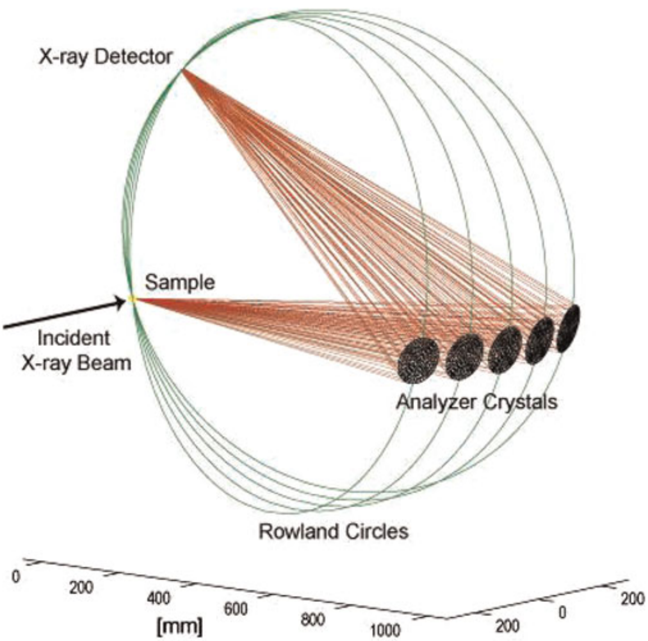

FIGURE 3. Schematic Rowland geometry.

With multiple pads, the weight can be well distributed while the frame geometry is maintained and the modal frequency is optimized. The computed simulation showed that the first modal frequency increased by 10 Hz when the feet were locked ($f_0 \approx 33$ Hz) (figure 5).

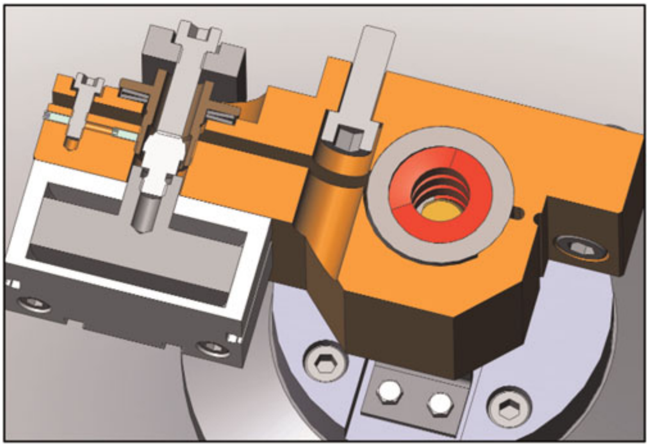

FIGURE 4. ID26 foot holder for air pads.

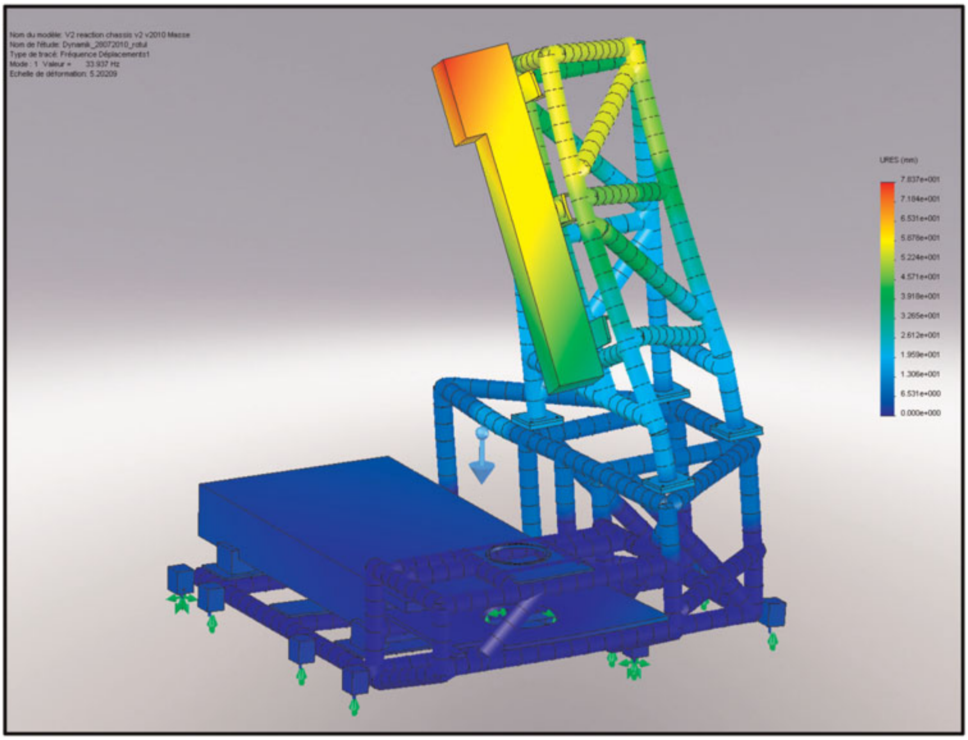

FIGURE 5. FEM modal simulation.

3. Results obtained on the ID26 emission spectrometer II

A detailed vibration analysis has been performed. A comparison is made with similar vibration measurements carried out on the previous version of this device, which was supported on the floor by eight rigid feet.

Results show a degraded stiffness in the horizontal direction at certain locations (granite table and analysers), but a minimal impact or an improvement at others

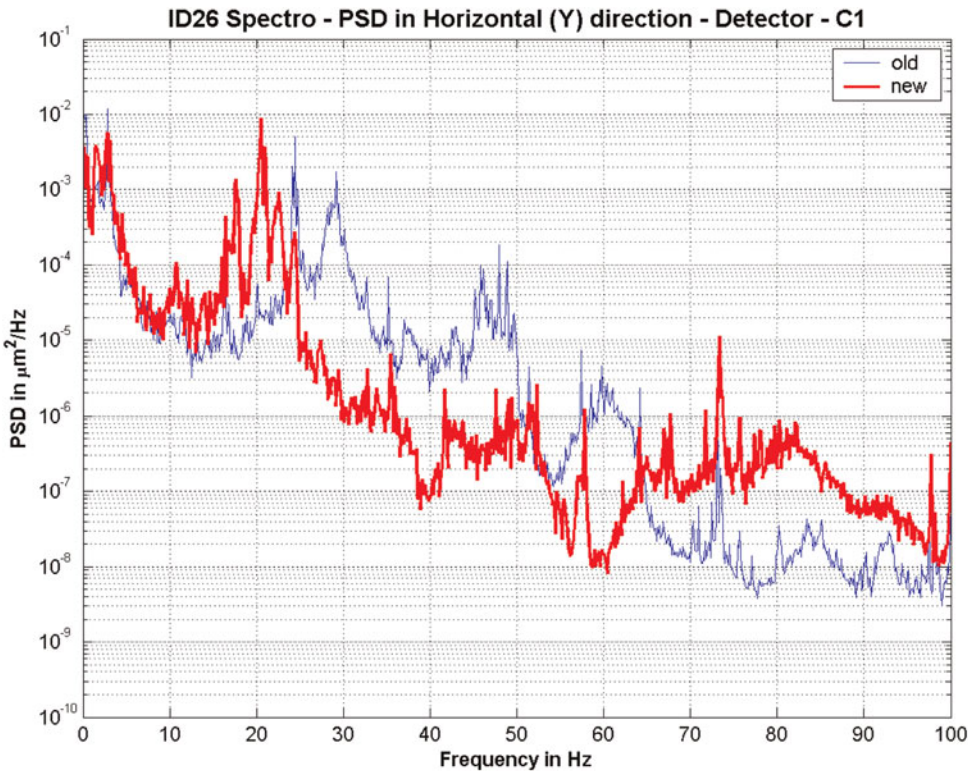

FIGURE 6. Detector horizontal (Y) displacement PSD – comparison of new and old spectrometers.

Sample	0.09	0.09	0.16
Detector	0.22	0.16	0.17
Analysers unit granite	0.25	0.15	0.22
Floor	0.08	0.09	0.17
Differential detector/analysers	0.38	0.24	N/A
	X	Y	Z

TABLE 1. Displacement μm r.m.s. in the range 0–100 Hz.

(detector and sample) (figure 6). A part of those differences can be attributed to a less rigid floor–structure interface of the new spectrometer, but another part could be explained by the new stages integrated in the new spectrometer (granite table *Z*-stage, which impacts analysers too).

The measurements show the same performance whether the foot holders are locked or unlocked. As expected, the results are worse when the air pads are activated.

Considering the instrument size and weight, and thanks to the design optimizations and calculations, the results are reasonably good (Table 1).